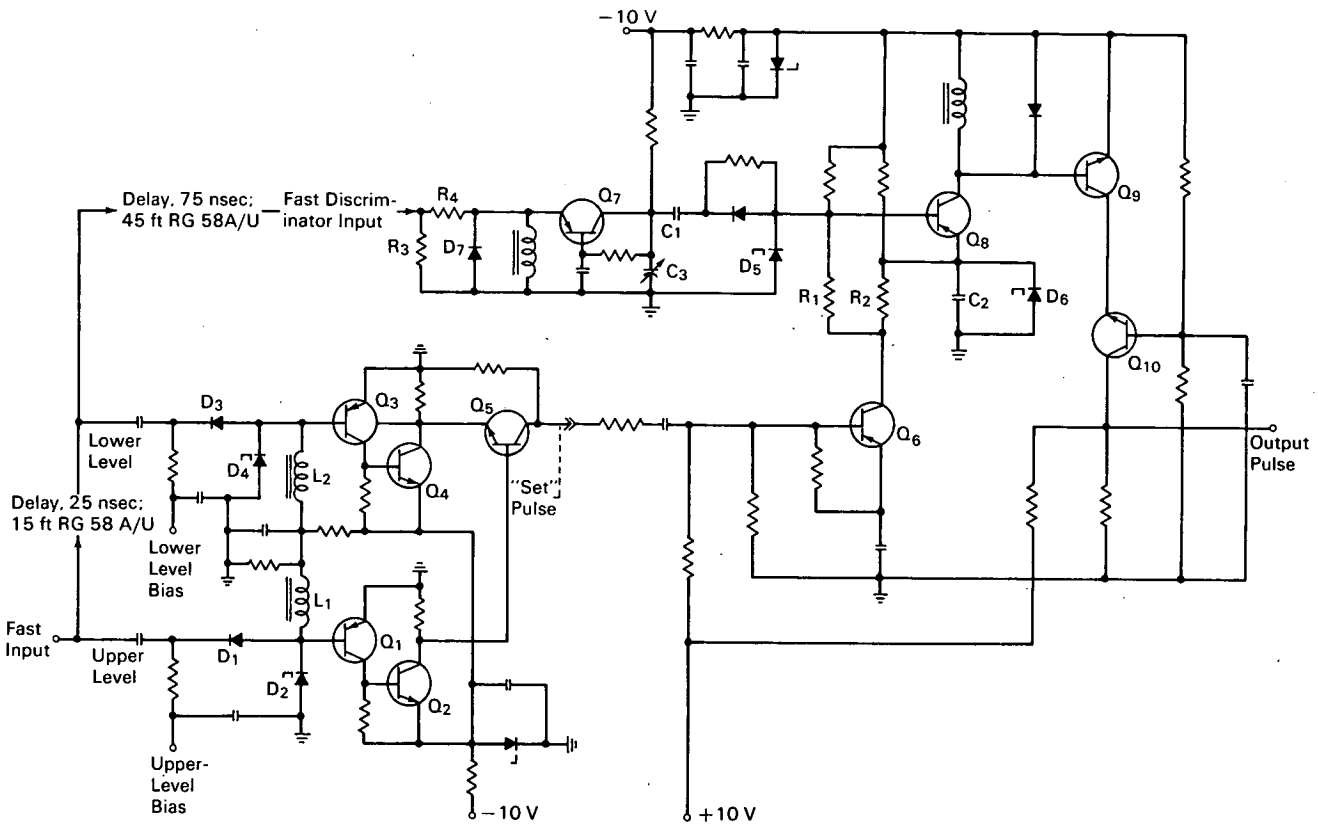
August 1966

Brief 66-10377

NASA TECH BRIEF

Single Channel Pulse-Height Analyzer Operates in Subnanosecond Range



SINGLE-CHANNEL PULSE-HEIGHT SELECTOR BOARD

FAST-DISCRIMINATOR BOARD

The problem:

To accurately measure nuclear state lifetimes shorter than 1 nanosecond. Detected particles do not commonly produce monoenergetic pulses but rather a whole spectrum of random pulse amplitudes. Because of this, the time response of a discriminator displays "time walk" as pulses of differing amplitude reaching the discriminator trigger threshold at slightly different times after their initiation. A second cause of timing error, "time jitter" is caused because a fraction of the pulses arrive at the discriminator while it is still subsiding from preceding pulses.

(continued overleaf)

The solution:

A single channel pulse-height analyzer that can handle approximately 10^4 random pulses per second above the lower discriminator level with negligible output pulse loss. By reversing the customary logic arrangement, "time-walk" is reduced and "time-jitter" is all but eliminated.

How it's done:

Input pulses are selected by the single channel pulse-height selector consisting of upper- and lower-level tunnel diode univibrator discriminators and an anti-coincidence circuit. The upper-level discriminator consists of D_1, D_2, L_1, and transistors Q_1 and Q_2, and the lower-level discriminator consists of D_3, D_4, L_2, and transistors Q_3 and Q_4. The upper- and the lower-level biases allow for discrimination of the fast input pulse. Transistor Q_5 is the anticoincidence element. Producing single channel selector action involves the application of the output of the lower-level discriminator to the emitter of Q_5 and the connection of the output of the upper-level discriminator to its base. In the absence of an upper-level discriminator pulse, Q_5 acts as a common base amplifier and produces a "set" pulse at its collector. If an upper-level discriminator pulse does exist, Q_5 is cut off and no "set" pulse is produced. In order to ensure anticoincidence action, the upper-level discriminator pulse is approximately 200 nanoseconds long and precedes the lower-level pulse, which is 125 nanoseconds long, by approximately 25 nanoseconds. The delay is produced by the insertion of 15 feet of RG 58A/U coaxial cable between the upper- and lower-discriminator inputs. The output ("set" pulse) of the anticoincidence circuit is shaped in transistor Q_6 and produces a short, positive pulse at its collector. This pulse places D_5 and D_6 in their low-voltage state due to current flow in R_1 and R_2.

The fast input signal, which is delayed a total of 100 nanoseconds, is terminated at the emitter of Q_7 by the parallel-series combination of D_7, R_3, and R_4. This delay is introduced to ensure that electrical quiescence exists in the fast-discriminator circuit after it has received a "set" pulse. The limited pulse produced at the collector of Q_7 is differentiated in C_1, and the resultant current pulse switches D_5 to its on state. The on voltage of D_5 causes Q_8 to conduct strongly until C_2 reaches the D_6 firing voltage, at which time Q_8 ceases to conduct. Any further pulse presented to D_5 before another "set" pulse has been received, cannot develop sufficient voltage in D_5, because of its high conductance in the on state, to cause further conduction in Q_8. The pulse produced at the collector of Q_8 is amplified and limited in Q_9 and Q_{10} and produces a quite uniformly shaped 5-volt negative pulse, the leading edge of which is well related in time to the fast input signal.

Notes:

1. To produce the best possible timing, variable capacitor C_3 is adjusted until the fast-discriminator inputs, as observed with a fast oscilloscope gated by the accompanying analyzer outputs, show the least "time walk".
2. This fast single channel pulse-height analyzer, mounted on two 2 1/2- by 3-inch circuit boards, is extremely stable and replaces a considerable amount of electrical circuitry previously used for this function, while providing excellent timing capability.
3. Further information concerning this innovation is presented in NASA TN D-2673, "Subnanosecond Time Resolution Single-Channel Pulse-Height Analyzer" by Theodore E. Fessler and William K. Roberts, February 1965, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151; price $1.00. Inquiries may also be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10377

Patent status:

No patent action is contemplated by NASA.

Source: (Lewis-267)